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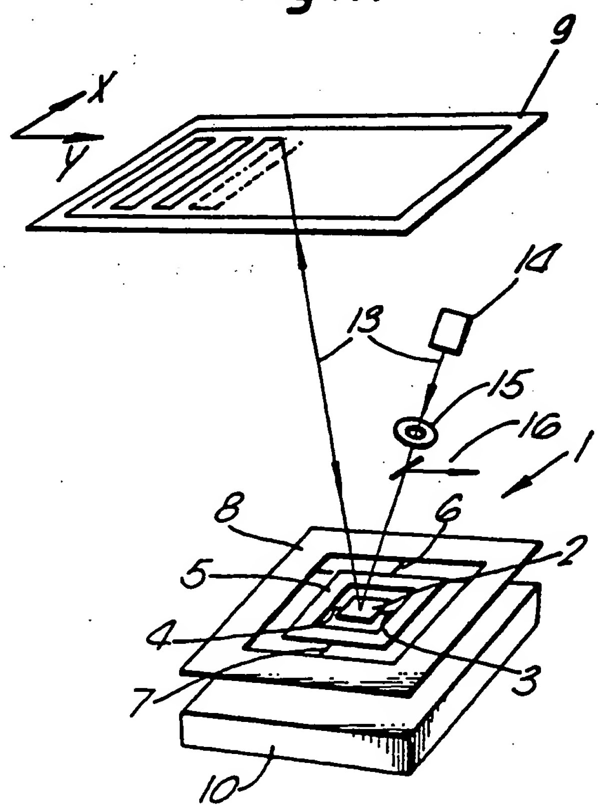
G2J
Selected US specifications from IPC sub-class G02B

(54) Dirigible reflector and mounting made of single crystal material

(57) A dirigible reflector in which the reflector 2 and its mountings 3–8 are formed integrally in single crystal material, for example silicon by selective etching. The reflector may be used in optical scanning system for reading/writing information stored optically on a member, for example a credit card.

Fig.1.



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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

Fig.1.

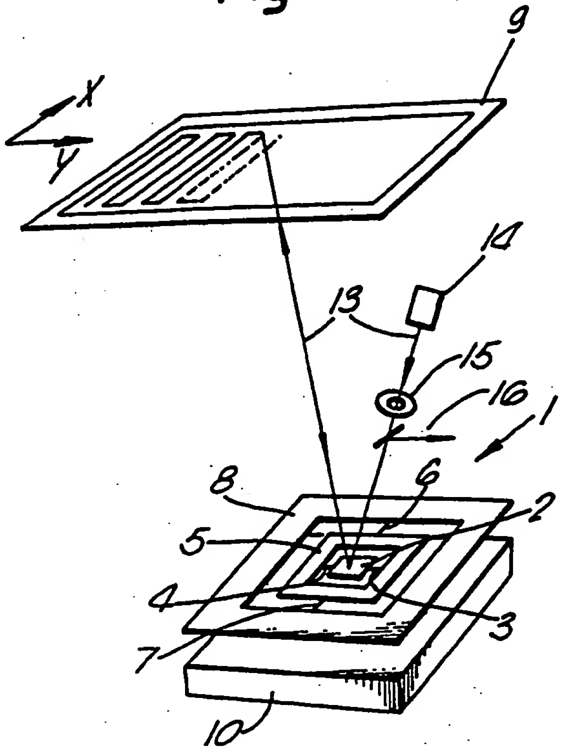
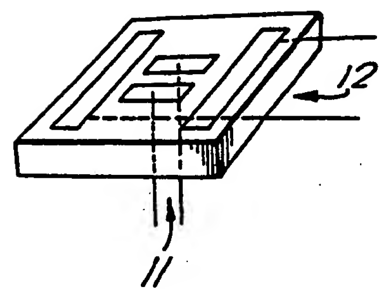


Fig. 2.



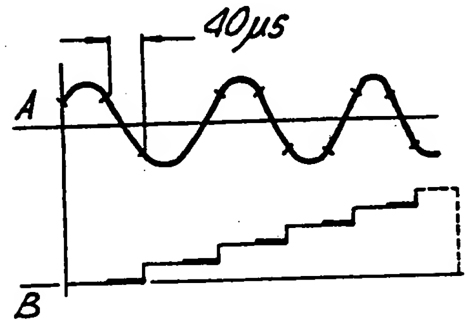


Fig. 3.

Fig.4a.

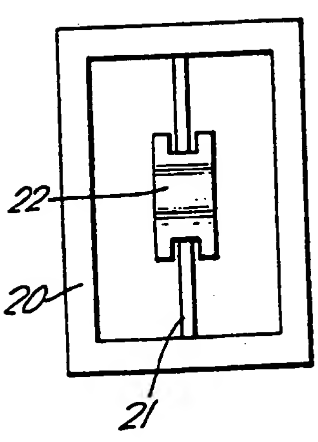


Fig.4b.

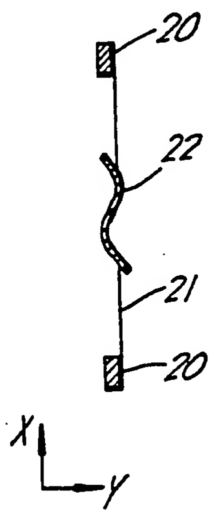
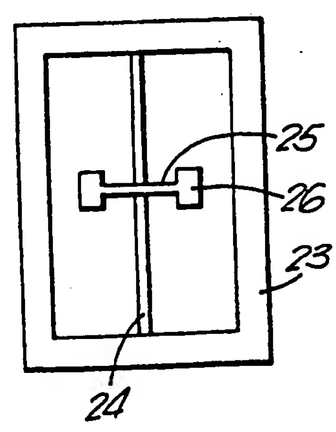


Fig.5.



SPECIFICATION

Optical elements

This invention relates to optical elements and in particular to dirigible optical reflectors and applications thereof.

High density optical storage techniques are being increasingly applied to areas typified by the conventional credit card with the appropriate demand for read/write facilities for use in association with them.

A present generation of readers is being developed involving mechanical transport of the card, usually along its long axis, by either continuous or stepper motors, and the transport of the necessary sensor arrays, charge coupled devices or others, across the short axis as a means of accessing the storage capacity of the card.

Multiple pre-recorded tracks containing coded information, or other locating devices to assist the accurate positioning of the read/write head, make considerable demands upon the overall capacity of the card. They are required, however, to mitigate the tolerance problems inevitably encountered with mechanical structures.

According to one aspect of the present invention there is provided a dirigible reflector in which the reflector and its mountings are formed integrally in single crystal material.

According to another aspect of the present invention there is provided a system for optically scanning a member for reading/writing of information stored optically on the member, the system including a dirigible reflector in which the reflector and its mountings are formed integrally in single crystal material, means for directing a light beam onto the member via the reflector, and drive means for steering the reflector whereby to scan the light beam over the member.

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:–

Figure 1 illustrates, schematically, scanning by means of a dirigible reflector element;

Figure 2 illustrates, schematically, the drive block of Fig. 1 together with drive elements;

Figure 3 is an example of timing diagram for the drives of Fig. 2, and

Figures 4a, 4b and *5* illustrate two other dirigible reflector element designs.

The present invention proposes the use of a dirigible reflector for interrogating a static area, for example a credit card, on which there is high density optical storag of information, or alternatively writing such information on such a static area.

The gimbal mount d reflector 1 illustrated in Fig. 1 comprises a first member 2 with a mirror-like surface and of extremely low mass which is freely pivoted at 3 and 4 to a surrounding frame-like member 5 which is in turn freely piv ted at 6 and 7 to a surrounding frame-like member 8, the pivots (gimbals) at 3 and 4 being align d with one another and perpendicular to the pivots (gimbals) at 6 and 7 which are aligned with one another. Thus members 2 and 5 are freely pivotable within member 8. Such a reflector 1 may be formed integrally in single crystal material such as silicon by selective etching. The members 2 to 8 of reflector 1 are thus formed from a single silicon substrate by chemical micro-machining. Such processing has previously been employed to manufacture devices, such as silicon resonators as described in British Patent Specification No. 1596982 (J.C. Greenwood 29). Although not so illustrated in Fig. 1, the reflector 1 may be encapsulated/evacuated depending on the preferred drive processes, and requisite damping. The chemical etching (micro-machining) enables a very thin, highly reflective and freely gimballed surface to be achieved by methods which ensure very small variations between one sample and the next within the production processes involved.

The "sculpted" silicon structure or reflector 1 is in use disposed relative to a static surface 9, for example a credit card, on which information is stored optically, which surface is to be interrogated. The surface may be optically pitted, for example. Associated with the reflector 1 is a drive element block 10. Fig. 2 shows a view of the drive element block 10 which indicated pairs of drives 11 and 12 for the reflector surface 2 and the frame-like member 5. The drive principles to achieve X and Y axis raster scan of the surface 9 by a light beam 13 reflected by reflector surface 2 may be sonic, electrostatic, electromagnetic, magnetostrictive, piezoelectric, air jet, pneumatic or other means compatible with the required response times and angular amplitudes.

The suspended surface 2 acts as a suitably dimensioned gimballed reflector. Its oscillation being controlled by the relevant suspension and/or drive elements, themselves part of a feedback loop responsible for accurately positioning the movement in the appropriate plane at any instant. The torsion of the silicon thus provides a control signal.

As illustrated in Fig. 1 the light beam 13 is produced by a collimated coherent source 14 and a light spot is caused to scan the surface 9 by movement of the surface 2. Reading of the information on the surface 9 is achieved over a reciprocal path, typically within an annulus of detectors 15 placed about the axis of transmission before deflection; by a beam splitting element 16 within the transmission path and a detector placed at an angle to it, or by the observation of interference patterns within the section.

In one arrangmenet it is envisaged that one axis of the refl ctor would undergo a r petitive linear sweep and the other axis would have a "staircase" characteristic, such that

the mirror surface 2 would caus the spot of coherent collimated light to generate a boustrophedon raster f precise characteristic.

Fig. 3 illustrates suitable timing diagram and waveforms from controlled feedback loops for a standard total scan of the surface 9, although other scan patterns can be accommodated if desired. A represents a linear sweep and at approximately 25Hz and B a staircase characteristic. B has up to 2.5×10^3 cumulative displacements before return to the base line, which involves movement approximately 100th/s.

The concept of a dirigible reflector surface 2 inevitably involves distortion of the minimum spot size away from the centre of the scanned area. By suitably dimensioning the collimated source it can be ensured that the ellipsoidal distortion of the rastered beam at the extremities of angular movement of the mirror surface will not exceed the dimensions of the individual element it is desired to read from the plane optical store (surface 9). Additional beam folding and beam forming optics will be dictated by mechanical design considerations.

Pre-printed tracks upon the surface 9 will be required in order to achieve precise location of any raster information written onto the surface during use of the credit card for example. These pre-printed tracks are typically constrained to the edges and selected other sections of the surface. Having accurately indexed the area of the raster within the area of the surface 9, relatively few other positioned checks should be required.

The low mass and controlled performance of the reflector surface 2, which may be additionally silvered, will ensure that high reading rates over the entire area of the optical store (surface 9) can be achieved and the servo control of the positioning (drive) elements will facilitate rapid interrogation of specific areas of the total optical store as may be required, when the store contains word processing or other expert programmes.

As mentioned above distortion of the minimum spot size away form the centre of the scanned area is inevitable, and since small laser sources are difficult to achieve, in certain applications the output of a conventional non-coherent source is channelled and conducted by a small optical fibre, of say 2 micron diameter, the end of which then constitutes the source. A lens is disposed between the fibre source and the reflector such that a spot size of 2 microns is achieved, after reflection, in the centre of an area typical of a standard credit card size and in such a fashion that the ellipse formed at the limits of the useful area of the card as a result of the maximum incident angle is still l ss than 5 microns. In this application the card therefore is scanned by a spot of light varying in siz from 5 to 2 microns depending upon the specific co-ordinate pattern within the raster.

The informati n may be coded by ph tographic means on the (front) surface of a r latively thick substrate (>400 microns), in terms of opaque or transparent active areas, indicated by 5×5 micron pixels, the pixels being separated by similar areas of 5×5 microns. Thus a single line scan may comprise a sequence of active areas comprising opaque, transparent, opaque, opaque, opaque, transparent, opaque, opaque etc. The progress of a scanning beam across such a line will result in the substrate being illuminated with energy entering via the transport area. If the back and three edges of the substrate are made significantly reflective and scattering, a single sensitive detector may be placed at the other edge of the substrate, then a series of light pulses will be detected at each passage of the scanning beam corresponding to the transparent areas and thus the data will be retrieved. Such an arrangement has a high tolerance to surface scratching of a credit card which is unavoidable in general use.

Alternative designs for the scanning mirror (reflector surface) are possible. It is difficult to obtain a fast sawtooth or staircase scan with a galvonometer mirror due to limits on the acceleration that the mirror can be subjected to. Sinisodial scanning can be obtained easily by operating the galvonometer at its resonant frequency. For many applications of an x–y scanning mirror the scanning frequencies in the two directions will need to be very different so as to give a faster type of scan. Thus for moving image application a typical Y or frame scan would be 50Hz and an X or line scan would be 20KHz, giving picture with 400 lines. The X resonator has to have a small angular inertia and a stiff suspension. Two possible designs are illustrated in Figs. 4a, 4b and 5 which may be employed instead of that illustrated in Fig. 1 for read/writing of information, or other scanning applications.

The design of Fig. 4a and 4b comprises a framelike member 20 on which, via a thin y-deflection torsion spring 21, is supported an x-deflector with a reflecting area 22. Fig. 4b which illustrates a section along the line IV–IV of Fig. 4a illustrates the mode of vibration of the x-deflector. The elements 20, 21 and 22 are formed integrally in single crystal material, e.g. silicon, by selective etching.

The design of Fig. 5 comprises a frame-like member 23 on which, via a thin y-deflection torsion spring 24, is supported an x-deflection torsion bar 25 at one of whose ends is provided a mirror 26. The elements 23, 24, 25 and 26 are formed integrally in single crystal material, e.g. silicon, by selectiv etching.

By means of the dirigible reflector, areas utilised for optical high density storage can be either read from or written into with high precision and speed. Th reduction of the possible card storage capacity by the necessity to

provide multiple tracks in the X and Y plane to contain discrete positional information is minimised.

CLAIMS

1. A dirigible reflector in which the reflector and its mountings are formed integrally in single crystal material.

2. A reflector as claimed in claim 1 wherein the material is silicon and the reflector is formed therein by selective etching.

3. A reflector as claimed in claim 1 or claim 2 comprising a mirror-like member freely pivoted within a surrounding frame-like second member for movement about a first axis, the second member being freely pivoted within a surrounding frame-like third member for movement about a second axis perpendicular to the first axis.

4. A reflector as claimed in claim 1 or claim 2, comprising a mirror-like member pivoted for movement in a first direction within a surrounding frame-like member by a thin torsion spring and adapted to vibrate in a second direction perpendicular to the first direction.

5. A reflector as claimed in claim 1 or claim 2, comprising a frame-like member, a thin torsion spring extending between opposite arms of the frame-like member in a first direction, a torsion bar disposed in the frame-like member on the torsion spring and extending in a second direction perpendicular to the first direction and a mirror-like member disposed at one end of the torsion bar.

6. A reflector as claimed in any one of the preceding claims and including drive means for steering purposes.

7. A reflector as claimed in claim 6 as appendant to claim 3 wherein the drive means include a respective pair of drives associated with each of said first and second axes.

8. A reflector as claimed in claim 7 wherein the drives operate according to one of the following principles, namely: sonic, electromagnetic, electrostatic, magnetostrictive, piezoelectric, air jet and pneumatic.

9. A system for optically scanning a member for reading/writing of information stored optically on the member, the system including a dirigible reflector in which the reflector and its mountings are formed integrally in single crystal material, means for directing a light beam onto the member via the reflector, and drive means for steering the reflector whereby to scan the light beam over the member.

10. A system as claimed in claim 9 wherein the light beam is provided by a coherent source whose utput is collimated.

11. A system as claimed in claim 9 or claim 10 and including means for detecting the respons f the member t the light beam.

12. A dirigible reflector substantially as herein described with r fer nce to Fig. 1, with or without reference to Fig. 2, Figs. 4a, and 4b, r Fig. 5, of the accompanying drawing .

13. An optical scanning system substantially as herein described with reference to the accompanying drawings.

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